DEMONSTRATION OF ABSORPTION OF CARBON DIOXIDE AND OF THE GENERATION OF OXYGEN BY DIATOMS.

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The essentially vegetable nature of diatoms is at the present time acknowledged by biologists almost or quite without exception. The phenomena of their increase and reproduction, if nothing else, are of a nature to call for their grouping in the same class with such undoubted plants as desmids and the Zygnemaceæ. Yet every young student, seeing for the first time the glassy cells of diatoms moving about under his microscope in a manner that would seem to indicate a very animal-like volition, is liable to ask for some tangible proof of their plant nature, some more elementary argument than that drawn from relations which are to be apprehended in all their significance only after somewhat extended study.

However difficult, or even impossible, it may be to draw a definite line that shall separate the animal and vegetable kingdoms, it is probable that no one will object if the term plant is applied to an organism which, when exposed to sunlight, is found to absorb carbon dioxide and to exhale oxygen. The method and apparatus described herein are designed to show that both these phenomena, which are so characteristic of plants in general, are characteristic of diatoms. Pelletan[1] states that he has collected sufficient of the gas arising from diatoms to serve for the application of those usual chemical tests which prove it to be oxygen. But it is not easy to bring together the conditions that permit the collection, from diatoms alone, of such a volume of gas as is required for these tests. Considerable time, also, must be needed for the operation. This question of time is, in fact, important to the success of the experiment; for in the absence of sunshine, or at least of bright daylight, it is found by experience that diatoms, and especially the motile forms that are expending energy in the way made evident by their motion, cease to exhale oxygen and begin to absorb it, or at least to give out carbon dioxide. This phenomenon,—the evidence of an exothermic chemical reaction,—the diatoms exhibit in common not only with

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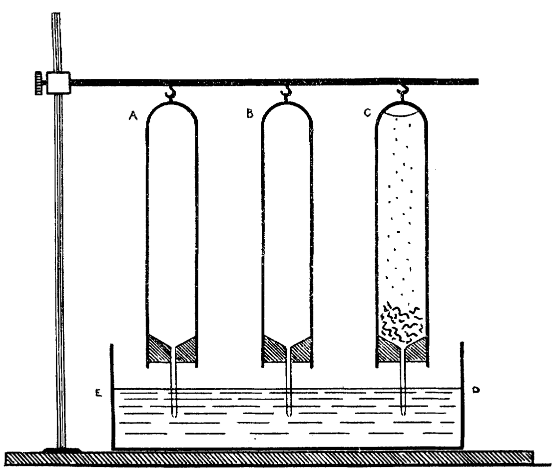
animal organisms but with all plants also. It is the well-known process of respiration, that which Gautier has called "the animal life of plants." The method I desire to describe is of great simplicity, and it yields conclusive results within an hour, provided the light be sufficiently strong; it does not necessitate the collection of any appreciable volume of gas, and it demonstrates both phases of the endothermic reaction.

Hæmatoxylin, the chromogen of logwood, is peculiarly fitted to be an indicator in a case where it is desired to recognize the presence or absence of carbon dioxide and the evolution of nascent oxygen, the solvent being ordinary water from spring or river containing its usual traces of various mineral matters. Under the influence of carbon dioxide, the hæmatoxylin dissolved in such water loses its normal rosy or slightly bluish-red tint, and turns to a yellow with a tinge of brown. In the presence of nascent oxygen, on the other hand, the light red hue deepens momentarily, and ends by becoming a very deep blood red. The latter change is in a manner permanent, but the former is reversible, *i. e.* the rosy red color returns when the carbon dioxide is removed. These well-known color reactions are of great delicacy, and are used in the following way:



A sufficient quantity of water is taken to fill all of the tubes shown in the figure, and the dish up to the mark DE. This is tinted with a sufficient quantity of a freshly made solution of hæmatoxylin. The color should be a very pale hue of red. The tube A is then

filled, and the rubber stopper, with its penetrating quill-tube, is inserted, the last bubble of air is forced out by pressure, and the tube suspended as shown. The remainder of the solution is acidified with carbon dioxide from the lungs, blown into it through a glass tube. The brownish-yellow tint having developed, tubes B and C are filled with the solution, and into C some clean, living diatoms are put. Both are then corked and hung as figured, the quill-tubes dipping below the surface of the liquid in the dish. These quill-tubes, which allow the pressure within the larger tubes, due to gas or to expansion from heat, to relieve itself into the dish, are drawn down to a very small opening in order to lessen diffusion of liquid up or down, and to confirm the diatoms. The apparatus is now exposed to bright light—if to direct sunlight so much the better, since the action is then more rapid. Gas arises from the diatoms in tube C, and simultaneously the color of the liquid, which is at first like that in B, begins to change. Within fifteen minutes, under proper conditions, the color has again become almost or quite as red as that in tube A. The carbon dioxide has now in large measure disappeared from the solution. The action continues, and the color in tube C deepens rapidly, showing oxidation; and this action continues until the color is quite blood-red, or even, in case much lime is in the water, until bluish lakes are formed in clouds. The ceasing of the action may, conceivably, be determined by exhaustion of every trace of carbon dioxide, but data on this head are wanting as yet. At all events the evolution of gas goes on long after the color reaction of carbon dioxide has disappeared.

The experiment may be varied in the following manner: All of the tubes are filled with the normal, non-acid, reddish solution of hæmatoxylin. Into A is put a living snail, into B live diatoms, and C is allowed to remain for comparison. The whole apparatus being exposed to sunshine, A pales rapidly under the influence of the carbon dioxide from the snail, while B as rapidly darkens and reddens compared with C, owing to the oxygen from the diatoms. This result, so significant, is obtainable in a very few minutes.

The diatoms selected for the above experiments were the long, broad filamentous forms of *Eunotia* (*E. major* of Rabenhorst), which are peculiarly applicable because it is easy to procure them in sufficient abundance, and to free them, under a dissecting microscope, from any accompanying algæ that might, by their presence, tend to acts doubt upon the conclusiveness of the results.